U.S. Fish and Wildlife Service
Office of Subsistence Management
Fisheries Resource Monitoring Program

Indexing the inseason abundance of salmon in the lower reaches of the Copper River Delta, 2004 Annual Report

Annual Report No. FIS 04-506

Alaska Research Associates, Inc.

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Annual Report Summary Page

Title: Indexing the inseason abundance of salmon in the lower reaches of the Copper River Delta, 2004 Annual Report

Study Number: FIS04-506

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EXECUTIVE SUMMARY

The purpose of this three-year project (2004-2007) is to generate a daily inseason index of early run salmon abundance in the lower Copper River, and to estimate the travel time of salmon from the commercial fishing area (Copper River District) to the test fishery at Flag Point Channel and the Miles Lake sonar site. This will provide Alaska Department of Fish and Game (ADF&G) fisheries managers with more timely escapement information than is currently available from the Miles Lake sonar site alone. The project builds on the results of a study conducted in the previous three years (2001-2004), which compared the utility of acoustics and drift gillnets as test fishing tools, developed a cost-effective method for acoustic sampling, and provided insights into fish migratory behavior in the study area.

In 2004, acoustic sampling at Flag Point Channel started on 9 May, one week before the Miles Lake sonar site was fully operational and eight days before the first scheduled fishing period. Acoustic sampling continued until 1 June 2004. Despite considerable amounts of river ice passing through the sonar site early in the season, we were able to sample for at least 14 h each day from 10 May to 13 May. Apart from minor disruptions, sampling was essentially continuous from 14 May to 1 June. We did not encounter any of the difficulties experienced in 2003, many of which appeared to be related to sampling in very shallow water. Visual echo trace counts were generated from the echogram during the first 15 minutes of each hour. As in 2001 and 2002, salmon echo traces were easily distinguished from eulachon. Daily counts, calculated by summing and expanding 15-minute counts, totaled 19,216 salmon for the period sampled, with a peak of 2,590 fish on 21 May. Counts up to 0700 hours of the current day were reported to ADF&G daily by 0900 hours.

As in 2001, 2002 and the second half of the 2003 sampling period, acoustic counts of salmon for Flag Point Channel provided a presence/absence index of salmon abundance. The counts also tracked the general trends in salmon abundance observed at the Miles Lake sonar site. The catch efficiency at Flag Point Channel followed a pattern similar to 2002, starting at more than 200 fish and gradually declining before leveling out at about 50 fish per 1,000 fish counted at Miles Lake. This pattern, if consistent in future years, may be used for a more quantitative index than mere presence/absence. Similar to previous years, estimated travel time ranged from 1 – 3 days between the sampling site at Flag Point Channel and Miles Lake (approximately 30 km distance) and 1 – 2 days between the Copper River ocean fishing district and Flag Point Channel (approximately 20 km distance).

INTRODUCTION

This project addresses subsistence fisheries-monitoring issues for Copper River sockeye *Oncorhynchus nerka* and Chinook *O. tshawytscha* salmon, as outlined under Stock Status and Trends by the Federal Subsistence Regional Advisory Council in the Fall of 2002 (OSM 2002). It addresses the need for annual collection and reporting of salmon stock assessment for stocks that support important federal subsistence fisheries. The main goal of this project is to index the abundance of salmon in the lower Copper River, and to provide fishery managers with more timely inseason information than is currently available from the Miles Lake sonar site. This project is currently funded from 2004 to 2006.

The extent of subsistence use of Copper River salmon stocks is substantial. According to the 2003-2004 Federal Subsistence Fisheries Regulations, subsistence harvests of salmon are scheduled to occur in the Upper Copper River District from 15 May to 30 September (OSM 2003). The Upper Copper River District contains the Chitina and Glennallen subdistricts, and consists of all waters of the mainstem Copper River from the mouth of the Slana River, downstream to a lower boundary approximately 200 meters upstream of Haley Creek. Copper River salmon are a federal subsistence resource with a customary and traditional use determination for certain rural Alaska residents, and can be harvested using fishwheels, dip nets, rod and reel and spears. In 2003, reported subsistence and personal use (Glennallen and Chitina subdistricts) harvests of Copper River salmon were 4,611 Chinook, 130,043 sockeye and 2,840 coho (Tom Taube, ADF&G, pers. comm.).

Copper River salmon provide an extremely valuable subsistence and commercial resource to local residents. Participation by native and non-native subsistence fishers is substantial, with over 10,000 people participating in the fishery each year. Recent annual ex-vessel value of the ocean commercial fishery has averaged $20 million. The ocean commercial fishery that targets Copper River salmon is located well downstream of the majority of the subsistence fishery harvesting. This distance represents two to four weeks travel time for salmon. As a result, the commercial fishery has the ability to harvest substantial numbers of salmon before the salmon are available to subsistence harvesters. Because salmon may reside for extended times within the commercial fishing district at the mouth of the Copper River, the gillnet fishing fleet can exert a significant harvest rate while fishing in the district as little as two days per week. Successful management of the commercial fishery thus has direct and important implications for providing sufficient salmon to upstream subsistence harvesters. However, the large commercial fishing district, temporal separation of the subsistence and commercial fisheries and heavy participation in the subsistence and commercial fishing sectors often makes it difficult for local fishery managers to balance the needs of the stakeholders while meeting their escapement goals.

The most important information salmon fishery managers rely on to manage fishing effort is the magnitude of the run to date, which is composed of cumulative escapement and catch. Catch is relatively easy to quantify, whereas the magnitude of escapement is usually much more difficult to obtain. Traditional commercial fishery performance indicators (e.g., catch per boat day) are not useful for providing inseason salmon abundance indices because of the large size of the commercial fishery and the erratic behavior of salmon entering the Copper River. The commercial fishing district is large and the fleet is mobile, making it difficult to obtain consistent sampling of the run by the fishery. Among-year variation in the early-season discharge from the Copper River appears to influence the rate at which fish enter the river and migrate upstream.

Salmon often spend considerable time milling off the mouth of the Copper River, waiting for ideal conditions to enter the system. Milling can provide high catch rates in the commercial fleet, which makes the run appear large when in fact there is little or no escapement to the river. This misleading information can threaten the availability of fish for upriver subsistence users. In contrast, if environmental conditions dictate rapid movement of fish through the fishery, it can result in excessive escapement and missed harvests for commercial fishers. Large missed harvests reduce the trust placed in fishery managers and increase pressure to open the fishery early in subsequent years. Clearly, timely (i.e., inseason) salmon escapement information from the Copper River is of great value to the subsistence and commercial fisheries of the area.

Many attempts have been made over the last 40 years to derive inseason estimates of salmon escapement in the lower Copper River (ADF&G 1962; Larson 1967; Larson and Fridgen 1968; Fridgen and Roberson 1970, 1971, 1972; Roberson and Fridgen 1974; Roberson et al. 1974; Roberson et al. 1980; Roberson et al. 1981; Roberson et al. 1982; Schaller 1984; Brady 1986; Morstad et al. 1991). Since 1978, the Alaska Department of Fish and Game (ADF&G) has operated the Miles Lake sonar site (river km 52 on the Copper River) from mid-May to early August as their primary assessment tool for inseason salmon management (Fig. 1). However, the Miles Lake sonar does not provide fishery managers with a reliable index of salmon abundance during the first few weeks of the commercial fishery. Without an indication of the magnitude of salmon escapement to the Copper River early in the run, fishery managers face difficult, controversial, and sometimes risky decisions of whether to open the fishery or leave it closed.

The lower river index is not intended to replace or duplicate the existing Miles Lake sonar site. Instead, its purpose is to provide a more timely index of salmon abundance that fishery managers can use in conjunction with the more precise but delayed information from Miles Lake to better manage the commercial fishery and ensure that an adequate number of fish make it upriver for subsistence harvests and spawning requirements.

In the spring of 2000, ADF&G once again began a field program to assess whether some form of test fishing could be developed in the lower Copper River (Steve Moffitt, ADF&G, pers. comm.). Drift dipnetting and gillnetting were explored as means of catching fish and indexing the escapement of sockeye salmon in the lower Copper River. The large number of possible routes for fish to travel upstream and limited sampling effort made it difficult to conclude whether or not a test fishery was feasible in this area. As a result, ADF&G recommended that additional effort and funding be applied to this study to further evaluate test fishing options.

In 2001, the Native Village of Eyak (NVE) partnered with ADF&G, LGL Alaska Research Associates, Inc. and Aquacoustics, Inc. to design and implement a multi-faceted three-year study to (1) significantly shorten the development time of a lower river test fishery; (2) study fish migratory behavior; and (3) compare the utility of acoustics and drift gillnets as test fishing tools (FIS01-021). Results from the first two years of this pilot study showed that the abundance indices generated using acoustics and drift gillnetting at Flag Point Channel (river km 22) were comparable to one another and tracked well with indices generated at the Miles Lake sonar site (Link et al. 2001; Lambert et al. 2003). Salmon were found to take between one and three days to travel the distance between Flag Point Channel and the Miles Lake sonar site and less than 48 hours to move from the commercial fishery in the Copper River District to Flag Point Channel (Link et al. 2001; Lambert et al. 2003). In 2003, extremely low water levels early in the season precluded significant salmon migration through Flag Point Channel and any meaningful assessment of passage by this project (Degan et al. 2004).

In 2001 and 2002, acoustic sampling was also performed at the Mile-37 Channel, located on the west bank of the river near Bridge 342 on the Copper River Highway. It was thought that acoustic data collected at the Mile-37 Channel could help explain trends in fish passage at Flag Point Channel as well as provide an alternative site for indexing salmon abundance in the lower Copper River. However, the short travel time of salmon from Flag Point Channel to the Miles Lake sonar reduced the value of Mile-37 as a potential index site. The benefits of sampling at the Mile-37 Channel appeared too small to justify the added cost to the project so it was discontinued after the 2002 season.

The three-year pilot study (2001–2003) also compared the relative strengths and weaknesses of acoustics and drift gillnetting to identify which technique would be the better choice for continued use on the lower Copper River (Degan et al. 2004). The authors concluded to discontinue drift gillnetting and use acoustics to index salmon abundance at Flag Point Channel. This conclusion was largely based on the substantially higher sampling power of acoustics and its ability to differentiate up- and downstream migration.

Objectives

This project builds on the results and experience gained in the three-year pilot study. Project objectives were to:

1) Generate a daily inseason index of early run salmon abundance in the lower Copper River to provide ADF&G managers with more timely escapement information than is available from the Miles Lake sonar site; and
2) Estimate the travel time of salmon from the commercial fishing area (Copper River District) to both the test fishery at Flag Point Channel and the Miles Lake sonar site.

Study Area

The Copper River flows through the Chugach Mountains of Alaska and drains into the northern limits of the Gulf of Alaska, east of Prince William Sound (Figure 1). Including its tributaries, the Copper River stretches more than 466 km and has created a 70-km wide delta of primarily glacial silt (Brabets 1997). The average annual discharge of the Copper River is 1,625 m^3/s, the second largest in Alaska. Despite carrying a very high sediment load, the Copper

River is one of the largest salmon-producing river in Central Alaska (Merritt and Roberson 1986) and supports abundant populations of sockeye and Chinook salmon.

The lower river sample site is located in the Flag Point Channel, 35 m below the first creek that enters the west side of the river downstream of Bridge 331 of the Copper River Highway (Figure 2 and Figure 3). This site is approximately 30 river kilometers downstream of the Miles Lake Sonar Station, and 20 river kilometers upstream of the Cordova Commercial Fishing District.

METHODS

The drift gillnetting program was discontinued in 2004 and Flag Point Channel was sampled with acoustic gear only.

Environmental Data

River stage height and weather information were recorded on most sampling days. Stage height was measured at a U.S. Geological Survey (USGS) gauge mounted on Bridge 331 and provided a relative measure of river elevation (the elevation of the bridge above sea level was not known). Stage height data were also obtained from a USGS gauge mounted on Million Dollar Bridge located at the outlet of Miles Lake. Weather information collected each day included cloud cover, precipitation, wind velocity (km/h) and wind direction.

Sampling Site Selection

The cross-sectional profile of the river bottom is typically an important factor when attempting to count migrating salmon with acoustic gear. A relatively continuous and smooth gradient is required for the conical acoustic beam to effectively sample fish swimming along the river bottom. For conventional sonar, the range where fish can be counted along the river bottom extends from about 1 m in front of the transducer out to the first significant break in the gradient of the river bank. Additional criteria for selecting an acoustic sampling site include:

1) Ice-free channel with flowing water;
2) Absence of debris, boulders or other objects that could interfere with the acoustic beam;
3) Bank with continuous, moderately steep slope above and below the water line;
4) Coverage of alternative migration routes (i.e., downstream of the confluence of multiple channels or upstream of diverging channels)
5) Ease of access; and
6) Previous observations of migrating salmon at the site.

In 2001, local fishers, biologists and fishery managers were consulted to locate a general area suitable for sampling salmon in the lower Copper River (Link et al. 2001). Additional information was gathered during road trips along the Copper River Highway and aerial surveys over the river at low water when channel morphology and potential sites were more evident. Once the Flag Point and Mile-37 channels were selected as potential sampling areas, bathymetry surveys were conducted to identify specific sites that were suitable for acoustic sampling.

In 2002, changes in the channel morphology and river conditions at Flag Point Channel were assessed during road trips and a reconnaissance flight. Another bathymetry survey was conducted in the Flag Point Channel to update and add more detail to the data collected in 2001 Figure 2) (Lambert et al. 2003).

In May 2003, channel morphology and river conditions were assessed from the Copper River Highway, during aerial flights and an on-site inspection during extremely low river height. The Flag Point Channel sampling site, was free of debris, had a gravel substrate and a uniform gradient with a -7° slope (Degan et al. 2004).

In April 2004, while low water exposed much of the sampling area, the site was again inspected. No major changes were found. The gradient of the site was still smooth and uniform but, compared to previous years, there was less debris embedded immediately upstream. The site appeared again suitable for acoustic sampling and no new bathymetry survey was conducted.

Equipment Setup and Operation

The acoustic system used in 2004 was a Simrad EK60 echosounder with a 4 x 9 degree, elliptical, splitbeam 120 kHz transducer and 50 m transducer cable. Given the extremely low water levels experienced in 2003, a longer transducer cable was used in 2004. This allowed the transducer to be easily moved further away from the bank into deeper water without relocating the electronic equipment and power supply. The transducer was deployed nearshore on the river bottom and aimed offshore, perpendicular to the river current, with the wide axis of the beam horizontal and the narrow axis vertical. The design of the transducer mount allowed adjustments in the vertical position and tilt angle of the acoustic beam (Figure 4). New in 2004, an analog tiltmeter (+/- 10° angular range, 0.5° resolution) was attached to the mount, such that its tilt was aligned with the transducer. This tiltmeter, which provided a direct read of the transducer tilt angle, allowed easy and controlled adjustment of the transducer on site without requiring access to computer data. A float switch was installed to automatically turn off the echosounder when the transducer becomes exposed to air, thereby preventing damage to its ceramic elements. We started taking this precaution after 2002, when a sudden and dramatic drop in water level left the transducer exposed for over 8 h.

The echosounder and the streamside power supply were installed at the same location used in the previous two years (Lambert et al. 2003). The streamside power supply consisted of a 12-V battery bank with a capacity of 700 amp hours, charged by two 75-W solar panels and a 50-W wind generator. Backup power was provided by a 2-kW gasoline generator.

A wireless system transferred data from the streamside echosounder to a laptop computer in the same travel trailer that had been used before (Degan et al. 2004). The trailer was again parked next to Bridge 1187 on the Copper River Highway, in clear line-of-sight directly opposite of, and about 1 km away from, the sampling site. In 2003, two separate notebook computers were used for data acquisition and data analysis. In 2004, one notebook computer (Dell D600, 512 MB RAM, 1.2 GHz Processor, 40 GB Storage) was used for data analysis while data acquisition ran in the background. This eliminated the need for a second notebook computer and further reduced power consumption. The wireless Ethernet link between the notebook computer and the acoustic system on the streamside allowed remote control of the acoustic system from the trailer. In addition, through a Starband satellite-internet connection, the computer could be accessed from any computer connected to the internet. The Starband system was upgraded from the Model 360 modem used in 2003 to a Model 480 modem, which provided four times faster upload speed. The Starband connection was used mainly for data transfer to Aquacoustics personnel who checked the counts and the quality of the acoustic data and provided technical support to the on-site crew. The power supply at the trailer consisted of a 12-V battery bank with a capacity of 700 amp hours and was charged by three, 75-W solar panels and a 400-W wind generator. Backup power was provided by a 2-kW gasoline generator.

To sample migrating salmon, the transducer was aimed along the river bottom. The aim of the transducer was verified using a plastic sphere (10-cm diameter) with target strength similar to an adult salmon. The sphere was lowered in front of the transducer using a fishing rod, raised 15 cm off the river bottom and then moved in- and offshore as much as water depth and current allowed. The aim of the transducer was confirmed when the target echoes were clearly visible and strong enough to qualify as salmon at least every 0.5 m. Fish were sampled with a transmit power of 200 W, ping rate of 14 pings per second, and a pulse length of 0.256 milliseconds. Unlike previous years, no amplitude threshold was used during data collection. Recorded data were therefore only limited by the –120 dB noise floor of the acoustic system.

A weir made from rebar and construction fencing was installed approximately 1 m downstream of the transducer and extended into the river about 1 – 2 m past the transducer. The weir kept fish from passing close to the transducer where the acoustic beam is not coherently formed or too small to efficiently detect fish. The weir had to be close to the transducer to prevent fish from coming back inshore before having passed the transducer. In addition, several pieces of rebar were put in about 20 m upstream of the transducer to direct ice floes offshore and away from the transducer. Unlike the weir, the ice deflection bars had to be at least 15 m upstream of the transducer to prevent the acoustic noise created downstream of an obstacle from interfering with the sonar beam. The position of the ice deflection bars also took advantage of the natural pattern of the river current, which, at that location, hit and was deflected off the river bank at a relatively steep angle. Technicians regularly removed debris from the weir and the transducer mount and wiped algae growth off the transducer face.

Data Analysis

The evaluation of different counting methods and sampling schemes conducted in the previous 3-year study led to the selection of visual 15-minute counts as the most efficient option to be continued in the current project. These counts were based on visually counting the number of salmon echo traces seen on the echogram, and disregarding the direction in which the target moved (i.e., upstream or downstream). Echograms were displayed in EchoView 3.00 software. Target strength (TS) echograms were used to separate salmon from smaller fish such as eulachon *Thaleichthys pacificus*. The maximum target strength in a track had to exceed –38.5 dB for the track to be counted as a salmon. The target strength was determined by comparing the colors on the echogram with the defined color palette or by moving the cursor over the echoes of a track and reading the tooltip display.

Technicians were shown how to use angle echograms as an aid when deciding whether given tracks were caused by a single fish (disrupted track) or multiple fish (Fig. A-2). The colors in angle echograms indicate the upstream or downstream angle at which the targets are seen. Targets in cool colors are seen on the downstream side of the transducer, while targets in warm colors are seen on the upstream side of the transducer. A fish that is moving upstream will typically be seen as a track that starts in dark blue, changes to light blue and turquoise as it approaches the center line of the beam, and turns green, yellow and eventually red as it leaves the beam on the upstream side of the transducer. The track of a fish that is moving downstream will change colors in reverse order (i.e., from red to yellow, green, turquoise, light blue and then dark blue).

Counts were done for the first 15 minutes of each hour. Daily counts were generated by summing and expanding the 15-minute counts (i.e., multiplying by 4). When data collection was interrupted, counts were expanded for missing hours by taking the average of the last good hour before the data gap and the first good hour after the gap.

RESULTS

Copper River Stage Height

Stage height of the Copper River was recorded at the Flag Point Channel West Bridge throughout the sampling period. At the Flag Point Channel East Bridge and the Million Dollar Bridge stage height data were collected starting 12 May (Fig. B-1; Table B-1). Throughout the sampling period, stage height was above 2.5 m at the Flag Point Channel and, with the exception of 14 May, above 40 m at the Million Dollar Bridge.

Equipment Setup and Operation

The acoustic system was operated at Flag Point Channel for a total of 513 h (94% of the time) from 1300 hours on 9 May to 0800 hours on 1 June 2004 (Table 1). Counts were interrupted for a total of 34 h during the season, due to heavy ice flow (27 h), transducer repositioning to accommodate rising or falling water level (2 h) and depleted power supply at the trailer (5 h).

A transducer pitch of -3.5 to -5° was maintained throughout the sampling period, yielding a counting range of 20 m until 23 May, when rising water allowed the transducer to be moved another 2 m inshore and the counting range was increased to 22 m for the remainder of the study period.

Differentiation Between Salmon and Eulachon and Fish Behavior

Visual review of target strength echograms showed very good separation of eulachon and salmon. Displaying the echograms at very low thresholds (-65 dB and lower) revealed eulachon tracks but these were easily discerned from the much stronger tracks left by salmon (Figure 5). Angle echograms indicated little to no downstream movement of salmon.

Acoustic Counts

Daily counts totaled 19,432 salmon for the period sampled (9 May – 1 June), with a peak of 2,590 fish on 21 May. Smaller local peaks occurred on 25 May (1,788) and 27 May (1,360) (Table 1 and Figure 6). It took the field technicians approximately 2.5 h to count a 24-h period. Aquacoustics staff checked a subsample of at least four 15-minute counts per day and provided feedback to the technicians within 24 hours. Validated counts were forwarded to NVE and ADF&G by 0900 hours each day.

Flag Point Channel as an Index of Miles Lake Counts

Similar to 2001 and 2002, relative changes in acoustic counts at Flag Point Channel mirrored the trends in the counts generated by the Miles Lake sonar. The comparison of time series plots of acoustic counts with Miles Lake data lagged 1, 2 and 3 days, indicated that a 2-day lag provided the best alignment of peaks and slopes of the Flag Point Channel and Miles Lake counts (Figure 6). Further inspection of the time series using a 2-day lag suggested two distinct changes in the ratio between the Flag Point Channel and Miles Lake counts, with the ratio dropping from 21-22 May and again from 25-26 May. In the periods between these changes, the counts at the two sites paralleled each other (Figure 7).

The 3-day moving average of the Flag Point Channel acoustics catch efficiency (Flag Point Channel index per 1,000 fish counted at Miles Lake) was compared to data from 2002 (Figure 8). Starting on 14 May 2004 (3 days before Miles Lake started to count for 24 hours on both banks), the Flag Point Channel catch efficiency was about 450; it then gradually dropped to about 50 by 27 May and remained constant for the remainder of the sampling period. In 2002, the Flag Point Channel acoustics catch efficiency started out lower (with about 250 Flag Point Channel counts per 1,000 fish counted at Miles Lake), and showed a similar but more stepwise (despite being averaged over 3 days) decline, and eventually reached a similar level as observed at the end of the 2002 sampling period. Note, in the above comparison, the 2002 data had been shifted one week back in time to account for the earlier apparent run timing in 2004. Also, in 2002, a 1-day lag was applied to the Miles Lake data (considered to give the best fit), whereas a

2-day lag was used in 2004 (see above). Data from 2003 were not included in the comparison because Flag Point Channel acoustic data were poor due to the extremely low water level (Link et al. 2001; Lambert et al. 2003).

In 2004, as in the previous three years, daily acoustic indices at Flag Point Channel decreased 1-2 days after the start of each commercial fishing opening in the Copper River District (Figure 7), suggesting that salmon migrated from the fishery to Flag Point Channel in about 1-2 days.

DISCUSSION

Technical Changes and Improvements

The setup and operation of the acoustics was similar to the pilot study, with a few technical changes. One of these changes relates to transducer aiming, which is one of the most important steps in acoustic sampling. In previous years, an attitude sensor was used that output transducer heading, pitch and roll information to a computer. The downside of this setup was that the person who waded into the water to aim the transducer required feedback from a second person reading the output from the computer at the trailer. Delays in the datastream made this process time-intensive and often frustrating. In 2004, we replaced the attitude sensor with a simple bubble tiltmeter attached to the side of the transducer mount, which allowed the person aiming the transducer to get instant feedback. Typically, using the tiltmeter as a guide, one technician was able to move and re-aim the transducer without requiring the help of a second person. The procedure was further facilitated by the automatic float switch, which made it possible for technicians to move the transducer without having to interact with the data collection software on the computer (located at the trailer). Data collection interrupted and resumed seamlessly and automatically. This significantly sped up and improved the process of moving and resetting the transducer. Quick and accurate resetting of the transducer was especially important early in the season when ice flow interrupted data collection more frequently. For quality control after the transducer was repositioned, Aquacoustics staff provided feedback based on echograms, either by logging on to the data acquisition computer or downloading data files.

No problems were encountered with the Simrad ER60 data acquisition software or the wireless system throughout the sampling period.

Once installed, the Starband system also performed very well. The upgrade to the faster modem was critical for transferring the acoustic data files, which were larger (5 MB for 7-minute file) than in the past because data were collected without threshold. As a future improvement, we are planning to automate data upload to expedite quality control of the acoustic data.

Merging the tasks of data acquisition and analysis to run on one computer significantly reduced the amount of power used (which is always an important consideration in a field camp). However, having just one computer increased the demand on the computer’s resources. The echogram scrolling speed decreased and the echogram display software crashed repeatedly, which increased the time it took technicians to prepare the counts. This should be remedied in the future by increasing the amount of RAM on the notebook computer. Further computer resources will be freed up by implementing automation that restricts data collection to the time period that is actually counted (15 minutes of the hour), rather than collecting data continuously. Automated data collection will give technicians time to review the data without data acquisition running in the background.

Sampling Conditions and Data Quality

As in 2001 and 2002, acoustic sampling conditions at Flag Point Channel were very good in 2004. Consistent display settings and the high quality of acoustic data made it easy to distinguish salmon from eulachon tracks (Figure 5). Having no threshold applied to data collection meant that data could also be viewed at lower display thresholds than in the past, which sometimes helped in the interpretation of the data. Review of angle color echograms indicated that very few salmon were moving downstream.

The total number of salmon counted, the good separation of salmon and eulachon, and fish behavior were comparable to the first two years of the pilot study. After the difficulties experienced in 2003, there was concern that the low-water conditions in Flag Point Channel were related to the Copper River shifting towards its eastern channels to an extent that would make Flag Point Channel unsuitable for sampling. Results from 2004 indicated that, for the time being, Flag Point Channel is still suitable for acoustic sampling. The highly dynamic delta remains, of course, unpredictable and the site will need to be reassessed every year before sampling.

Index and Travel Time

Fishery managers recognize two broad but useful levels of precision for "indexing" in-river escapement from the commercial fishery in the Copper River District: presence/absence and a more quantitative measure such as: more than a few hundred fish, less than 20,000 fish, etc. Each year, in the earliest stages of the salmon run (mid-May), managers simply want to know whether or not there are fish present in the river upstream of the commercial fishery. This is sometimes enough information to influence management decisions. In 2004, as in every year since its inception, with the exception of 2003, the Lower River Test Fishery accomplished the goal of determining when fish first entered the river in significant numbers.

However, it has also become clear that the number of salmon sampled at Flag Point Channel does not represent a fixed percentage of the number of salmon counted at the Miles Lake sonar site. This is not surprising since Flag Point Channel is only one of several alternative migration routes, and we sampled just one side of the channel. Nevertheless, as long as there is a systematic component in how the percentage sampled at Flag Point Channel varies, it will still be possible to establish an index that is more precise than mere presence or absence. The trend observed in 2004 is consistent with the data from 2002, with the catch efficiency in both years starting at more than 20%, then gradually declining, and leveling out at around 5%. Only data collected over additional years will tell how consistent this pattern is from year to year and how precise the index will be in the medium to long term. The decline in the relative number of fish sampled at Flag Point Channel is consistent with the sequence in which the channels of the Copper River Delta break up in spring and reports from local fishermen who observed that, early in the run, salmon tend to aggregate (and presumably enter the river) on the west side of the delta and only later shift towards the east. Channels in the vicinity of Flag Point are among the first channels to become ice-free. Early fish may therefore be more likely to migrate through Flag Point Channel than fish entering later when more alternative routes become available.

The systematic variation in the percentage of fish sampled at Flag Point Channel was also reflected by the general alignment of peaks and troughs in the Flag Point Channel and Miles Lake counts observed throughout the 2004, 2002, 2001 and in the second half of the 2003 sampling period. Again, this suggests that it may be possible to obtain an index that goes beyond mere presence or absence.

Some of the variation in the index, measured by the ratio of Flag Point Channel and Miles Lake counts, presumably stems from variation in the observed fish migration speed (which may change with river conditions), from fish navigating different channels or from fish changing their behavior otherwise (e.g., actual swimming speed, resting). Similar to previous years, when comparing the time series of Flag Point Channel and Miles Lake sonar counts it appears that different lag times improve the match of the two indices for different time periods. In 2004, a 3-day lag provided the best fit early on, while a 1 to 2-day lag led to better alignment in the second half of the sampling period (starting around 21 May). Changes in the migration speed will introduce additional variation in the ratio of Flag Point Channel and Miles Lake counts, even if the acoustic gear at Flag Point Channel samples a constant proportion of fish entering the river. Ultimately, it is the number of fish entering the river, rather than a precise forecast of Miles Lake counts, that is of interest.

The speed at which fish migrated from Flag Point Channel to Miles Lake (1-3 days for approximately 30 km) was similar to the apparent speed of migration from the commercial fishing district to Flag Point Channel (1-2 days for approximately 20 km). Given the speed of migration, the Flag Point Channel index provided information on the number of fish entering the river that was 1 – 3 days more up-to-date than the Miles Lake sonar counts.

An advantage of the Lower River Test Fishery project arises from the early start-up date. In 2004, acoustic sampling at Flag Point Channel began on 9 May, one week before the Miles Lake sonar site was clear of ice and fully operational and 8 days before the first scheduled commercial fishing period. It is early in the season, when high fish prices add to the pressure on managers to open the commercial fishery, that up-to-date information on whether and how many fish have entered the river is especially important.

CONCLUSIONS

1) The quality of the acoustic data was very good. Salmon were easily distinguished from eulachon. We did not encounter any of the difficulties experienced in 2003 that were related to sampling in very shallow water. Flag Point Channel remained suitable for sampling.
2) Flag Point Channel counts provided a clear presence/absence type index and mirrored the general trends in the Miles Lake counts. Trends in the catch efficiency over the study period were similar to those observed in 2002. If this pattern is consistent in the future then these data may be used for a more quantitative index.
3) The apparent fish migration speed was similar to previous years. Overall, a 2-day lag between Flag Point Channel and Miles Lake produced a better match than 1 or 3 days. Fish appeared to take 1 – 2 days to travel from the commercial fishery in the Copper River District to Flag Point Channel.

RECOMMENDATIONS

For 2005, we recommend to:

1) Continue to use acoustics to sample at Flag Point Channel, unless channels change significantly before May 2005; and continue to provide a daily inseason index of abundance;
2) Examine the among-year variability in the ratio between the Flag Point Channel and Miles Lake counts;
3) Examine the among-year variability in fish behavior and migration speed;
4) Automate data collection and data upload, increase RAM on the notebook computer and preassemble the power setup in "plug-and-play" modules; and
5) Investigate options for streamlining and expediting pre-season mobilization.

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Special thanks to NVE technician Joanna Reichhold and ADF&G technician Amy Lindsley who conducted the acoustic fieldwork. Erica McCall Valentine, Bruce Cain and Keith van den Broek (NVE) provided logistical support that was instrumental to the success of this project. Justin Burket (Ebbtide Electronics) provided invaluable assistance with power supply and communications setup. Jason Smith and Michael Link (LGL) reviewed earlier drafts of this report. Steve Moffitt (ADF&G) provided river stage height information. We also thank everyone who attended the workshop in Cordova and provided valuable feedback on the project.

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FIGURES

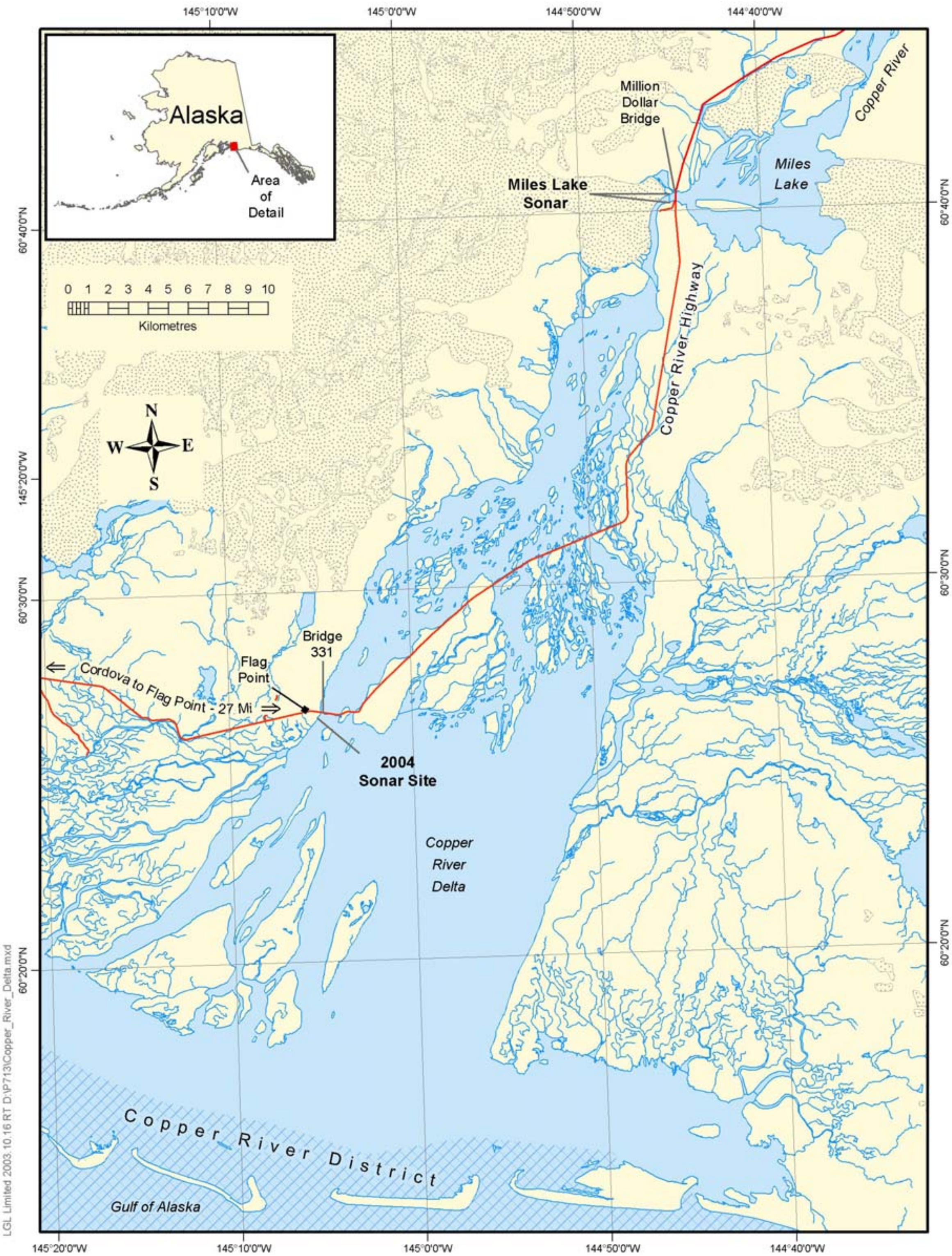

Figure 1. Map of the lower Copper River in Alaska showing the location of Flag Point Channel and the Miles Lake sonar site, 2004.

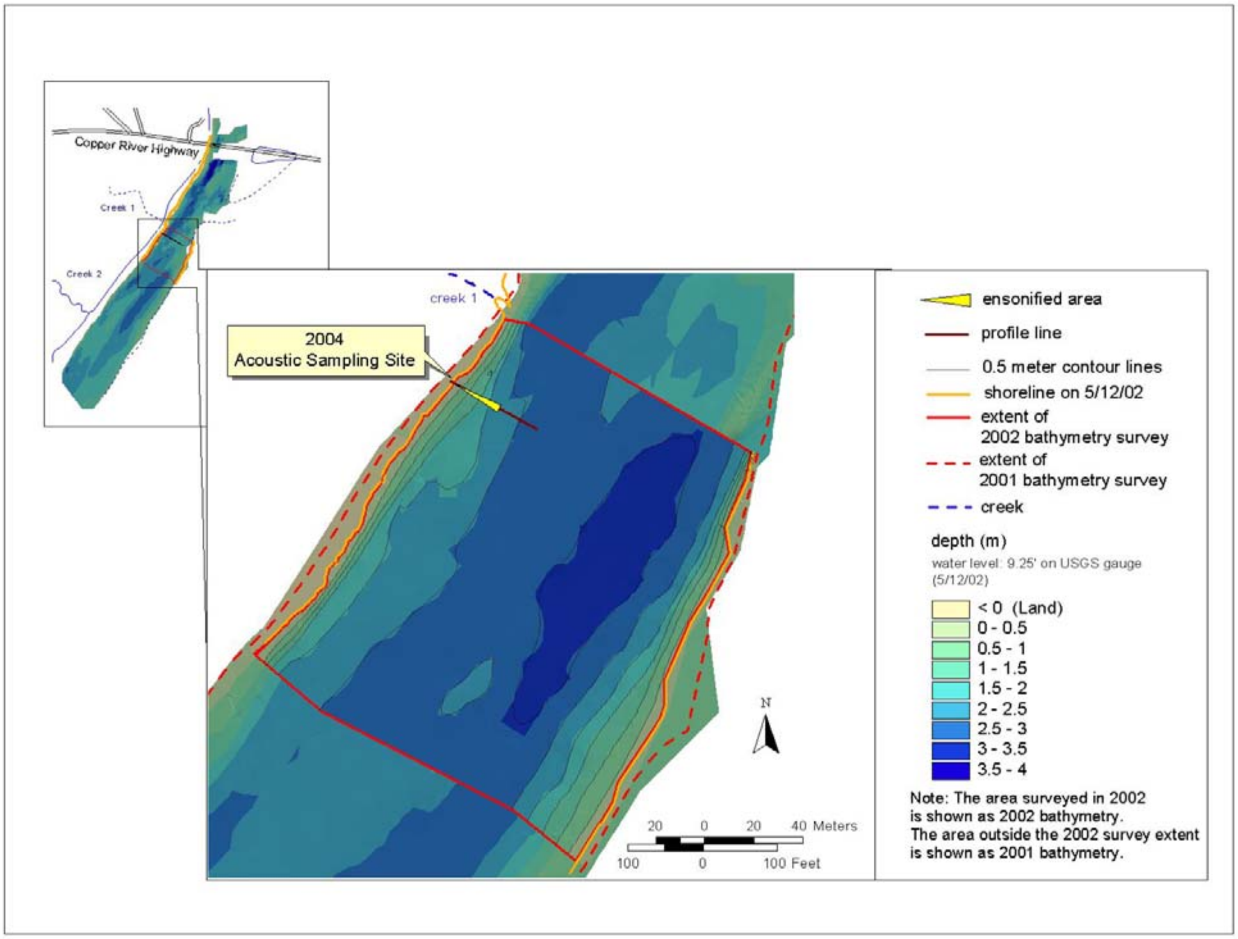

Figure 2. Bathymetry of the Flag Point Channel acoustic sampling site used in 2002, 2003 and 2004. The site was located 400 m downstream of Bridge 331 on the Copper River Highway.

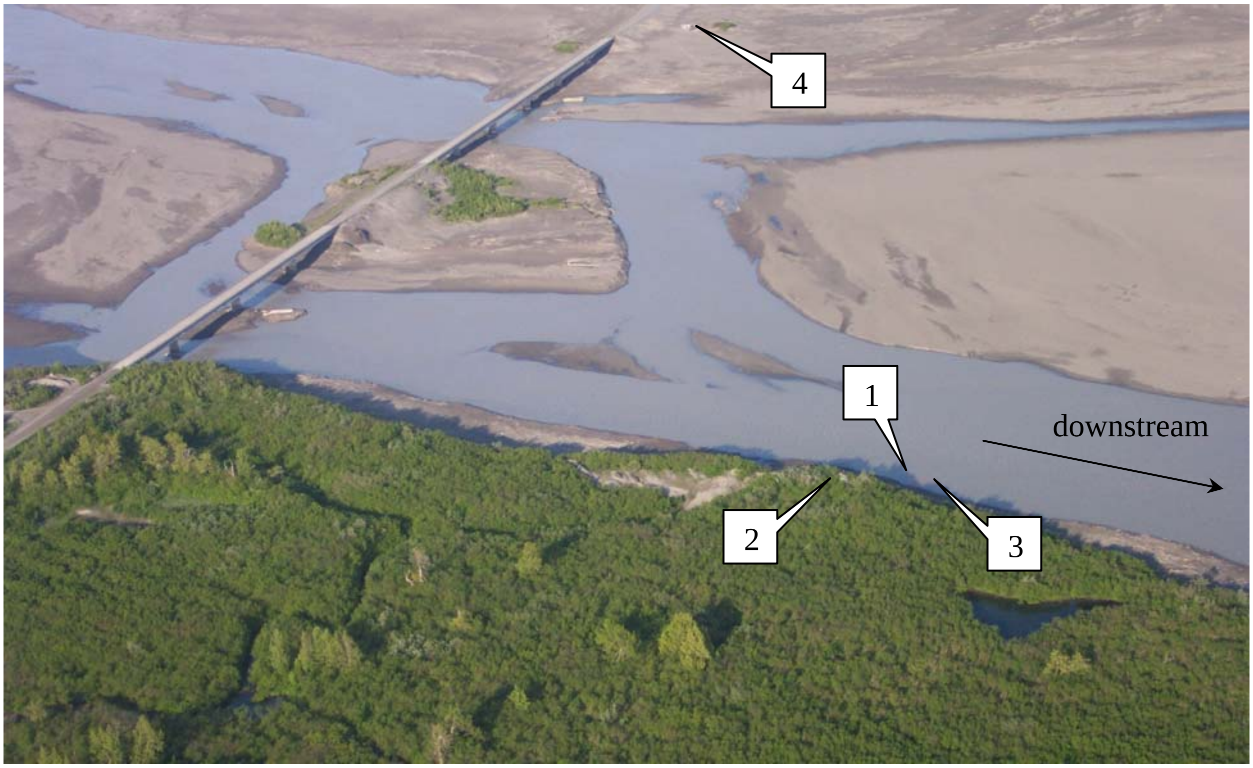

Figure 3. Aerial photograph of the Copper River Highway (Mile 27) and Flag Point Channel. Shown are the locations of the (1) transducer, (2) platform, (3) weir and (4) travel trailer that served as the data retrieval and processing station and accommodation for the technicians. The photograph was taken on 3 June 2003 at a stage height of 2.6 m on the USGS gauge on Bridge 331.

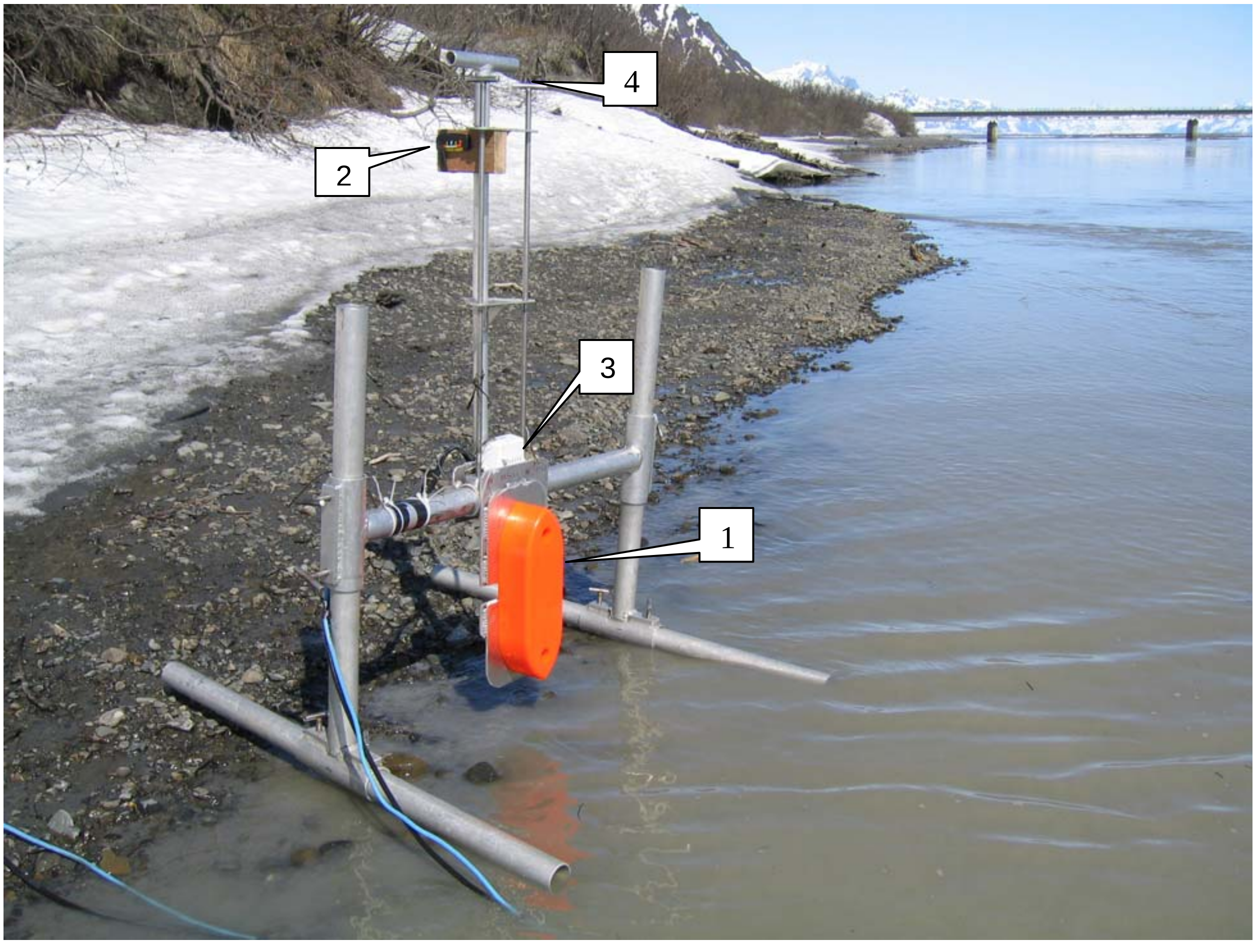

Figure 4. Transducer mount with (1) Simrad transducer, (2) tiltmeter, (3) float switch and (4) set screws for adjusting the vertical position and tilt angle of the transducer.

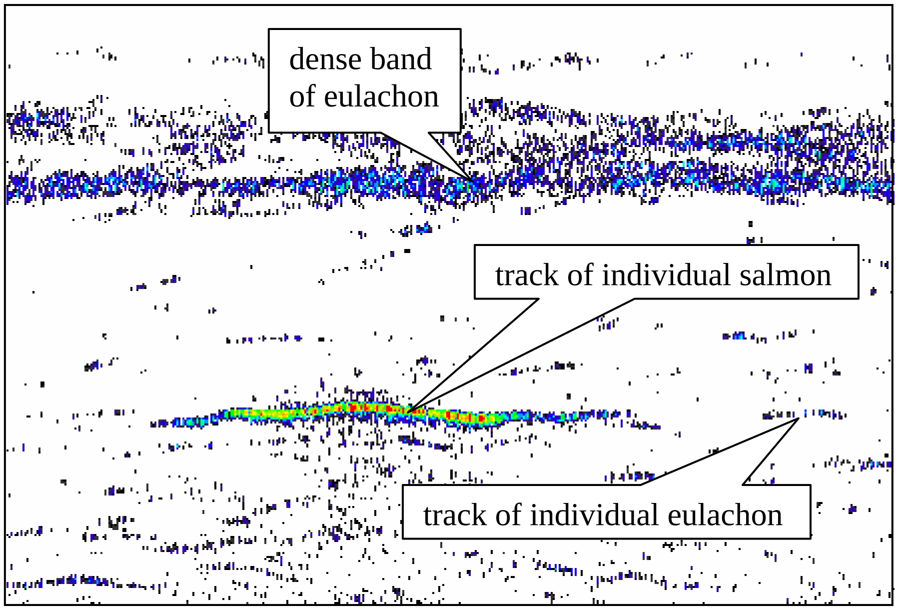

Figure 5. Differentiation between salmon and eulachon. Echogram was recorded on 14 May 2004, and displayed in EchoView with a -54 dB display threshold and 40 dB display range.

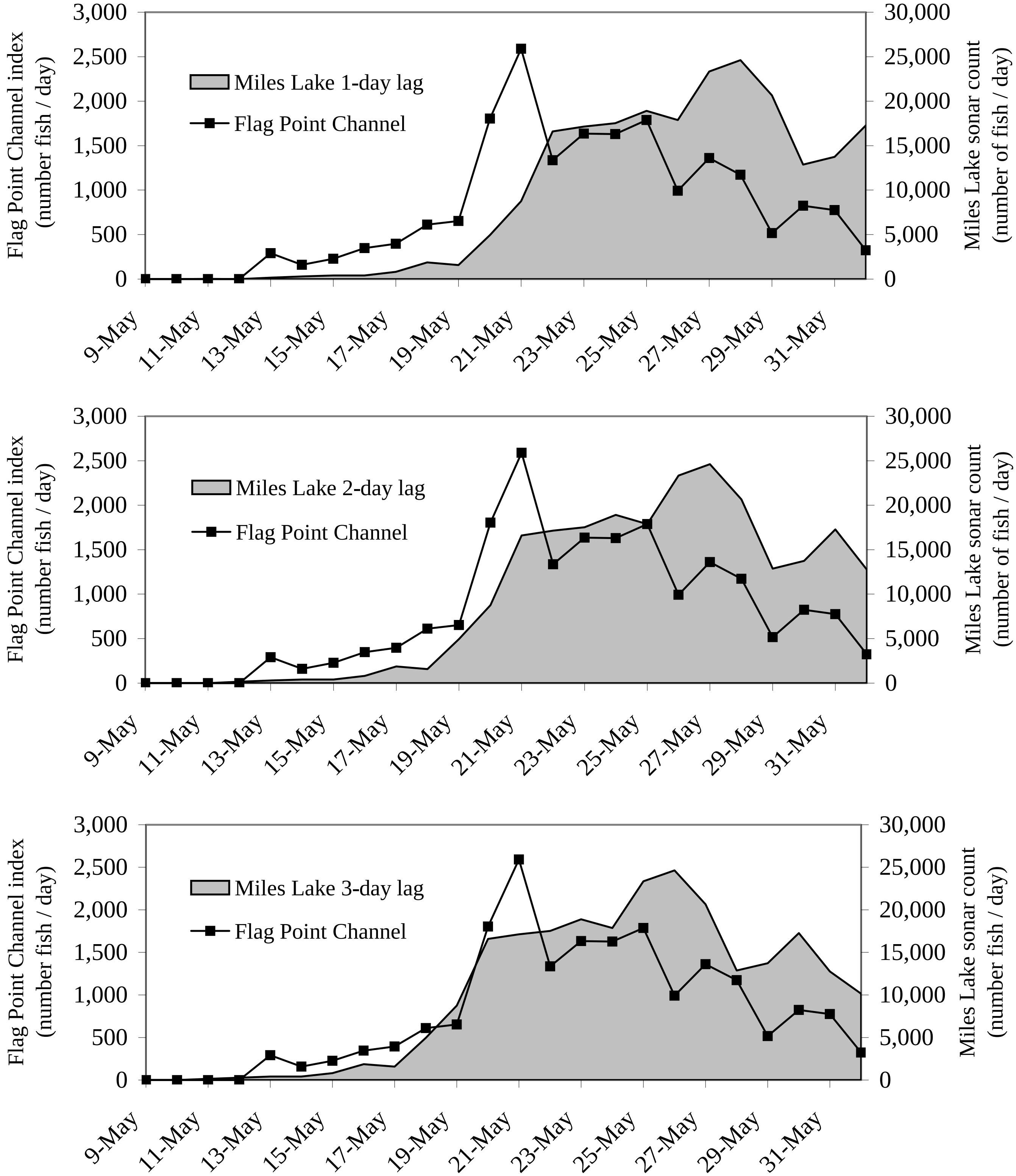

Figure 6. Comparison of the daily Miles Lake sonar counts, lagged 1 day (top), 2 days (middle) and 3 days (bottom), and the Flag Point Channel acoustic indices, 2004.

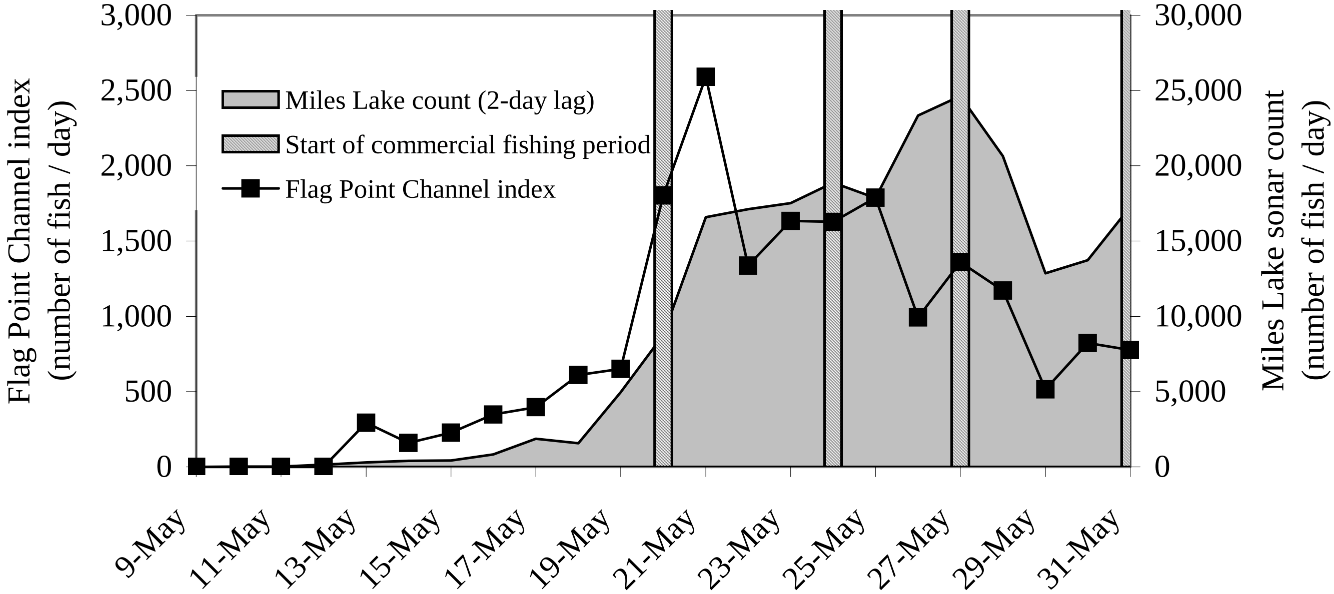

Figure 7. Daily acoustic indices for salmon at Flag Point Channel, sonar counts from Miles Lake and the starting dates of commercial fishing openings in the Copper River District, 2004.

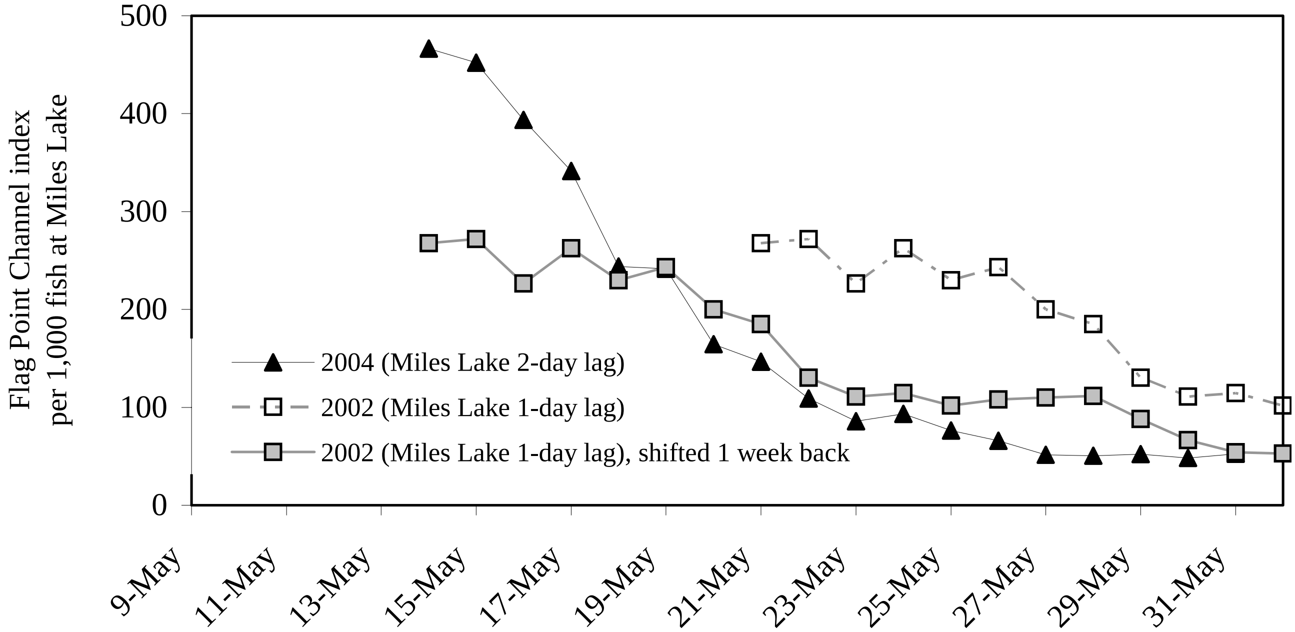

Figure 8. Catch efficiency of Flag Point Channel acoustics, as measured by the ratio of the Flag Point Channel Index to the Miles Lake Sonar count (index per 1,000 fish counted at Miles Lake; 3-day moving average). For 2004, data series starts with the day the Miles Lake sonar became fully operational. The 2002 data are shown for comparison, including a data series shifted back 1 week to coincide with 2004 pattern.

TABLES

Table 1. Time and range sampled by acoustics and daily fish counts at Flag Point Channel, 2004.

Date	Range sampled (m)	Hours sampled	Percent of the day sampled	Count	Comments
9-May	20	11	46	0	1300 hours: start of data collection
10-May	20	15	63	0	0500 - 1200, 2200 - 2400 hours: counts interrupted due to heavy ice flow
11-May	20	14	58	0	0000 – 0800, 2100 - 2300 hours: counts interrupted due to heavy ice flow
12-May	20	23	96	0	0300 - 0400 hours: noise, possibly ice hung up on transducer
13-May	20	17	71	292	0300 - 1000 hours: water level dropping rapidly, transducer exposed
14-May	20	24	100	160	
15-May	20	24	100	228	
16-May	20	24	100	348	
17-May	20	24	100	396	
18-May	20	24	100	612	
19-May	20	24	100	652	
20-May	20	24	100	1,804	
21-May	20	23	96	2,590	2000 - 2100 hours: water level rising, moved transducer inshore
22-May	20	24	100	1,336	
23-May	20	23	96	1,634	1900 - 2000 hours: water level rising, moved transducer inshore
24-May	22	19	79	1,628	1400 - 1900 hours: trailer power supply depleted
25-May	22	24	100	1,788	
26-May	22	24	100	992	
27-May	22	24	100	1,360	
28-May	22	24	100	1,172	
29-May	22	24	100	516	
30-May	22	24	100	824	
31-May	22	24	100	776	
1-Jun	22	8	33	324	0800 hours: end of data collection
Total		513	89	19,432	

APPENDICES

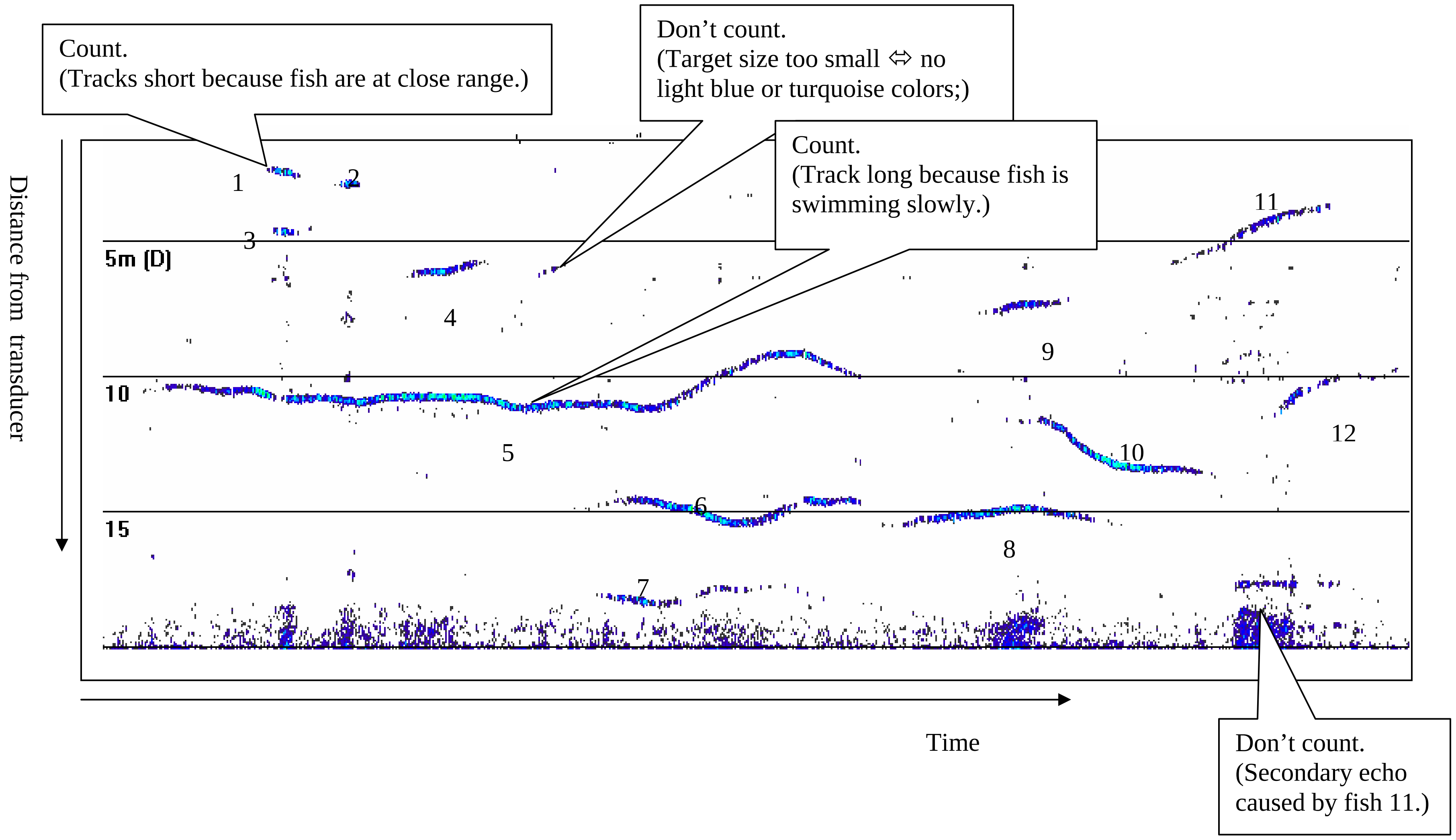

Figure A-1. An EchoView® target-strength echogram showing track examples with guidelines for visually counting salmon-sized fish. (Display properties: color display minimum = -55 dB; color display range = 40 dB

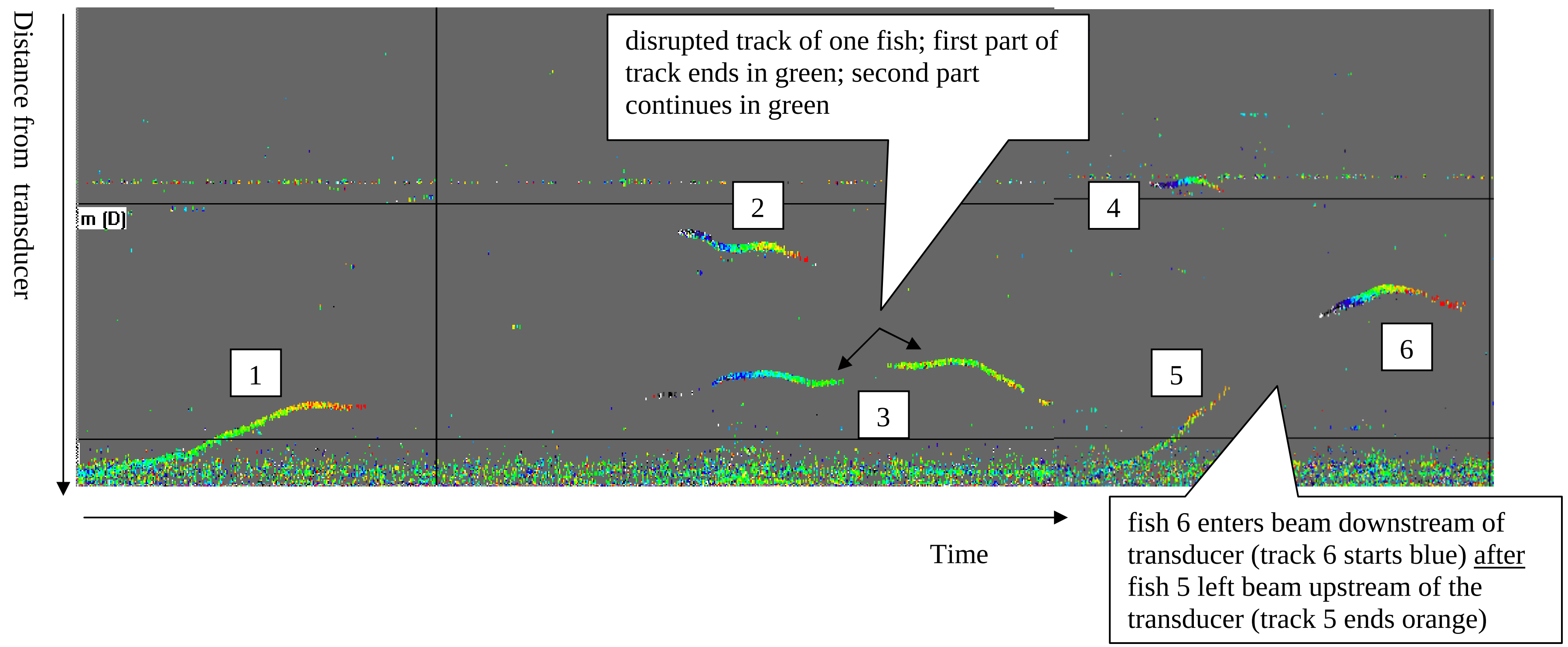

Figure A-2. An EchoView® angle echogram showing track examples with guidelines for distinguishing a disrupted track caused by a single fish from tracks caused by multiple fish. Targets in cool colors are on the downstream side of the transducer, targets in warm colors are on the upstream side of the transducer (display properties set to major axis angle range: +/- 8°; major axis color scheme: DT4; minor axis color scheme: none.).

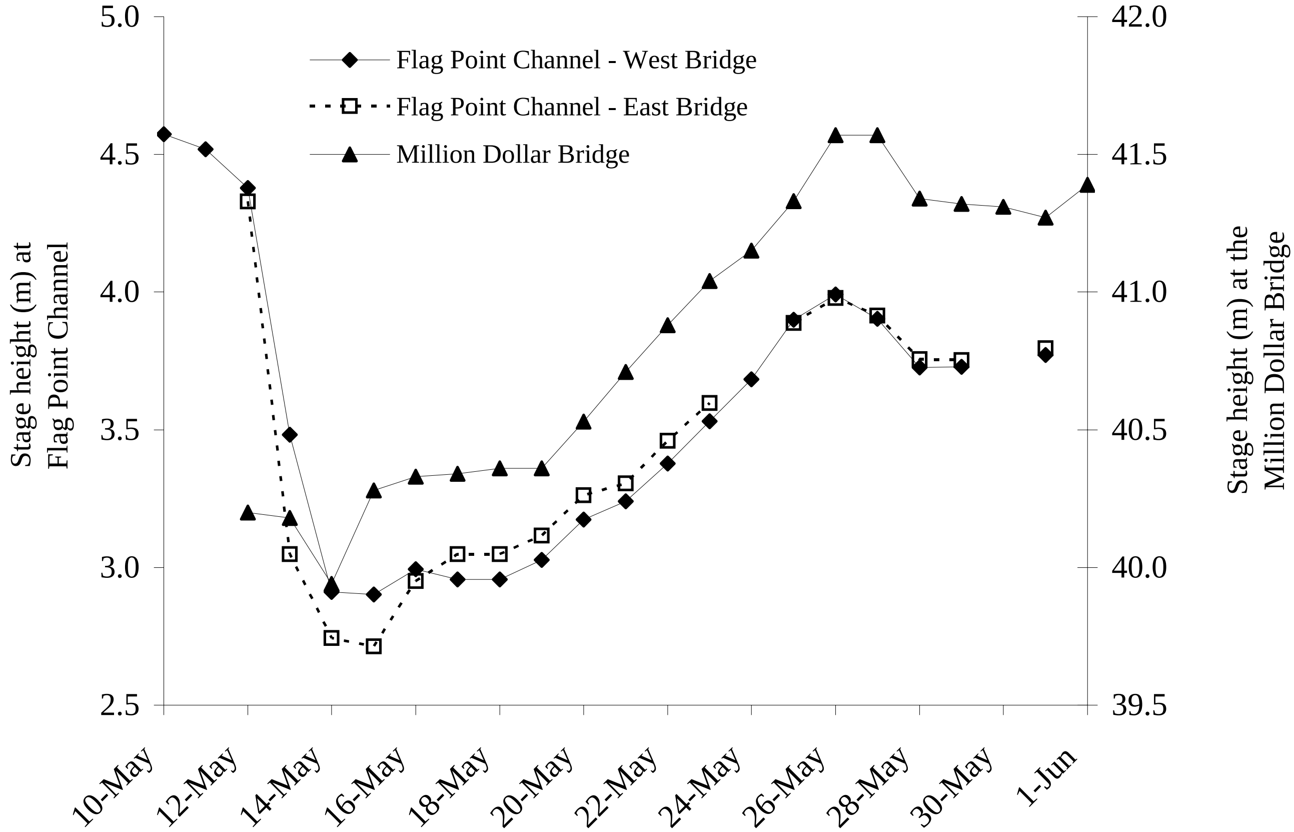

Figure B-1. Stage height of the Copper River at Flag Point Channel and the Million Dollar Bridge, 2004.

Table B-1. Stage height (m) of the Copper River at Flag Point Channel and the Million Dollar Bridge, 2004. Stage height was measured using USGS gauges and is a relative measurement as the current bridge elevations above mean sea level are unknown.

	Flag Point Channel		Million Dollar Bridge
Date	West Bridge	East Bridge	
10-May	4.57		
11-May	4.52		
12-May	4.38	4.33	40.20
13-May	3.48	3.05	40.18
14-May	2.91	2.74	39.94
15-May	2.90	2.71	40.28
16-May	2.99	2.95	40.33
17-May	2.96	3.05	40.34
18-May	2.96	3.05	40.36
19-May	3.03	3.12	40.36
20-May	3.17	3.26	40.53
21-May	3.24	3.30	40.71
22-May	3.38	3.46	40.88
23-May	3.53	3.60	41.04
24-May	3.68		41.15
25-May	3.90	3.89	41.33
26-May	3.99	3.98	41.57
27-May	3.90	3.91	41.57
28-May	3.73	3.76	41.34
29-May	3.73	3.75	41.32
30-May			41.31
31-May	3.77	3.80	41.27
1-Jun			41.39

Table C-1. Daily salmon counts and escapement objectives at the Miles Lake sonar, 2004.

		Estimated daily escapement				Escapement objective	
Date	Stage height (m)	North Bank	South Bank	Daily	Cum.	Daily	Cum.
12-May	40.2	14		14	14		
13-May	40.18	12		12	26		
14-May	39.94	150		150	176		
15-May	40.28	64	230	294	470	0	0
16-May	40.33	88	324	412	882	11	11
17-May	40.34	72	347	419	1,301	407	418
18-May	40.36	96	725	821	2,122	973	1,391
19-May	40.36	216	1,648	1,864	3,986	1,358	2,748
20-May	40.53	128	1,451	1,579	5,565	1,526	4,275
21-May	40.71	336	4,624	4,960	10,525	1,558	5,832
22-May	40.88	528	8,233	8,761	19,286	2,093	7,925
23-May	41.04	576	16,012	16,588	35,874	3,034	10,959
24-May	41.15	800	16,330	17,130	53,004	4,668	15,628
25-May	41.33	496	17,024	17,520	70,524	4,727	20,354
26-May	41.57	696	18,194	18,890	89,414	4,971	25,325
27-May	41.57	560	17,303	17,863	107,277	7,187	32,512
28-May	41.34	536	22,811	23,347	130,624	9,422	41,935
29-May	41.32	1,624	23,001	24,625	155,249	6,635	48,570
30-May	41.31	1,208	19,436	20,644	175,893	7,963	56,534
31-May	41.27	488	12,371	12,859	188,752	10,588	67,122
1-Jun	41.39	848	12,883	13,731	202,483	11,008	78,129
2-Jun	41.42	472	16,809	17,281	219,764	12,491	90,620
3-Jun	41.35	392	12,358	12,750	232,514	12,061	102,681
4-Jun	41.27	320	9,809	10,129	242,643	13,665	116,346
5-Jun	41.26	536	14,814	15,350	257,993	15,085	131,431
6-Jun	41.45	408	16,049	16,457	274,450	13,617	145,048
7-Jun	41.61	384	5,936	6,320	280,770	13,382	158,430
8-Jun	42.11	560	12,284	12,844	293,614	15,555	173,985
9-Jun	42.35	664	14,284	14,948	308,562	14,894	188,879
10-Jun	42.37	392	12,768	13,160	321,722	14,279	203,157
11-Jun	42.23	376	9,856	10,232	331,954	13,754	216,911
12-Jun	41.99	296	13,122	13,418	345,372	12,732	229,643
13-Jun	41.77	320	14,879	15,199	360,571	11,185	240,828
14-Jun	41.59	144	8,414	8,558	369,129	10,754	251,582
15-Jun	41.65	120	10,714	10,834	379,963	11,516	263,099

Table C-1 (continued). Daily salmon counts and escapement objectives at the Miles Lake sonar, 2004.

Date	Stage height (m)	Estimated daily escapement				Escapement objective	
		North Bank	South Bank	Daily	Cum.	Daily	Cum.
16-Jun	41.79	104	12,457	12,561	392,524	10,287	273,386
17-Jun	41.95	48	8,031	8,079	400,603	10,275	283,661
18-Jun	42.28	64	9,273	9,337	409,940	8,783	292,444
19-Jun	42.67	216	12,724	12,940	422,880	7,688	300,132
20-Jun	43.13	168	14,572	14,740	437,620	7,953	308,085
21-Jun	43.52	200	12,653	12,853	450,473	7,181	315,266
22-Jun	43.79	56	9,457	9,513	459,986	7,167	322,432
23-Jun	43.89	256	10,277	10,533	470,519	7,500	329,932
24-Jun	43.99	840	9,415	10,255	480,774	7,349	337,282
25-Jun	44.17	672	7,250	7,922	488,696	7,347	344,629
26-Jun	44.25	704	6,376	7,080	495,776	6,404	351,033
27-Jun	44.35	360	5,125	5,485	501,261	6,210	357,243
28-Jun	44.41	376	6,402	6,778	508,039	6,121	363,364
29-Jun	44.41	280	5,625	5,905	513,944	6,116	369,479
30-Jun	44.34	192	5,861	6,053	519,997	5,604	375,083
1-Jul	44.21	264	9,086	9,350	529,347	5,803	380,886
2-Jul	44.10	136	8,477	8,613	537,960	5,876	386,762
3-Jul	44.01	na	8,551	8,551	546,511	5,959	392,722
4-Jul	43.96	144	8,084	8,228	554,739	6,764	399,486
5-Jul	43.89	88	8,726	8,814	563,553	6,620	406,106
6-Jul	43.66	86	6,672	6,758	570,311	6,391	412,497
7-Jul	43.54	88	8,276	8,364	578,675	6,161	418,658
8-Jul	43.64	144	10,006	10,150	588,825	6,570	425,228
9-Jul	43.81	64	7,109	7,173	595,998	6,725	431,953
10-Jul	43.93	156	5,974	6,130	602,128	7,312	439,265
11-Jul	43.84	56	5,646	5,702	607,830	6,537	445,802
12-Jul	43.90	32	8,318	8,350	616,180	7,255	453,057
13-Jul	44.02	16	5,751	5,767	621,947	6,318	459,375
14-Jul	44.08	8	4,627	4,635	626,582	6,947	466,322
15-Jul	44.16	24	4,840	4,864	631,446	6,966	473,288
16-Jul	44.22	24	2,812	2,836	634,282	6,772	480,060
17-Jul	44.36	96	1,228	1,324	635,606	5,781	485,840
18-Jul	44.56	48	798	846	636,452	6,367	492,208

Table C-1 (continued). Daily salmon counts and escapement objectives at the Miles Lake sonar, 2004.

Date	Stage height (m)	Estimated daily escapement: North Bank	South Bank	Daily	Cum.	Escapement objective: Daily	Cum.
19-Jul	44.56	32	789	821	637,273	6,979	499,187
20-Jul	44.22	16	1,348	1,364	638,637	7,174	506,361
21-Jul	43.87	58	2,469	2,527	641,164	5,764	512,125
22-Jul	43.73	48	2,502	2,550	643,714	4,423	516,548
23-Jul	43.78	48	2,972	3,020	646,734	4,211	520,759
24-Jul	43.39	48	3,730	3,778	650,512	3,303	524,062
25-Jul	43.29	77	2,261	2,338	652,850	2,850	526,912
26-Jul	43.09	80	2,908	2,988	655,838	2,594	529,506
27-Jul	43.05	48	2,913	2,961	658,799	2,753	532,259
28-Jul	43.14	34	2,253	2,287	661,086	2,887	535,146
29-Jul	43.55	29	1,653	1,682	662,768	2,827	537,973
30-Jul	43.60	16	3,337	3,353	666,121	2,499	540,472
31-Jul	43.60	64	3,461	3,525	669,646	2,058	542,530